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(54) **METHOD AND APPARATUS FOR
IMPROVING ACCURACY OF A/C
DIAGNOSTIC TESTS**

7,832,222 B2 * 11/2010 McMasters 62/149
2002/0162351 A1 11/2002 Findley et al.
2006/0236705 A1 10/2006 Govekar et al.
2007/0006609 A1 1/2007 Thomas et al.
2011/0160918 A1 6/2011 McMasters et al.

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CPC **F25D 15/00** (2013.01)

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F25B 2700/04; B60H 1/00585; F25D 15/00
USPC 62/77, 292, 149, 125
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,141,977 A * 11/2000 Zugibe 62/149
6,185,945 B1 2/2001 Pfefferle et al.

OTHER PUBLICATIONS

Kool Kare User's Manual, Snap-on Technologies, 1998 [retrieved on
Apr. 24, 2013]. Retrieved from the internet: <URL:http://www.
snaponequipment.com/Common/UserManuals/UM-EEAC104B.
pdf> Introduction and pp. 1-1 to 3-14.
International Search Report and Written Opinion for PCT/US2013/
025871 filed Feb. 13, 2013.

* cited by examiner

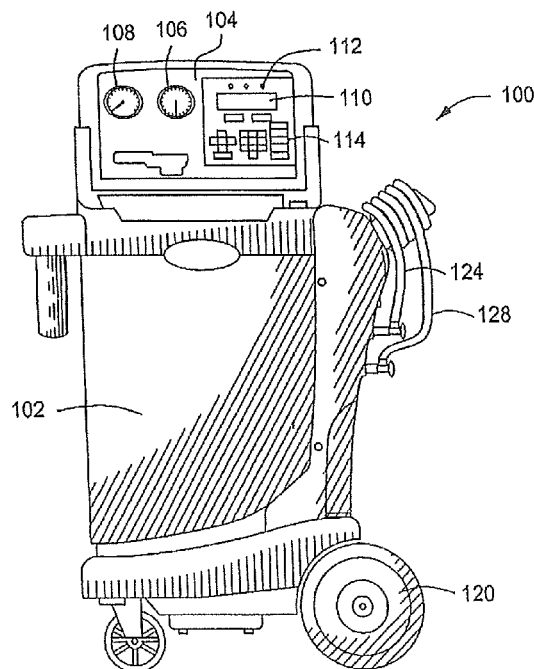
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(57) **ABSTRACT**

An apparatus and method are developed to improve accuracy
of diagnostic tests for A/C systems. In particular, a refrigerant
recovery unit may have its hoses pre-charged with a refrigerant
to a predetermined pressure or amount before performing
the diagnostic tests on the A/C system of the vehicle. For
example, a predetermine amount of refrigerant may be
injected into the hoses of the refrigerant recovery unit to
pre-charge them. The pre-charged hoses of the refrigerant
recovery unit may prevent a refrigerant flow from the A/C
system to the hoses connected thereto before the diagnostic
tests are implemented and thus, improve the accuracy of the
diagnostic tests.

9 Claims, 3 Drawing Sheets



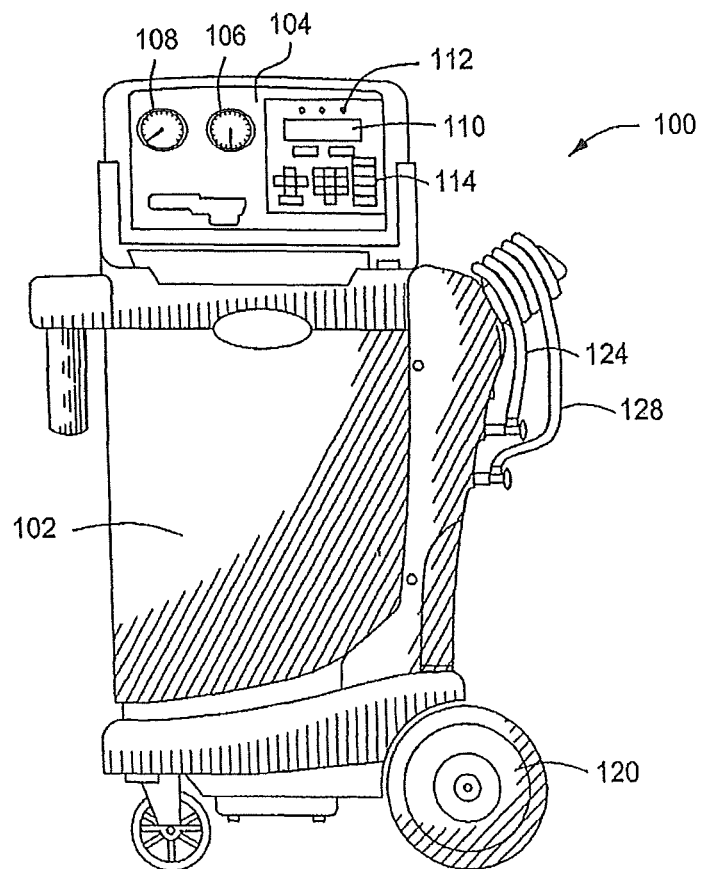
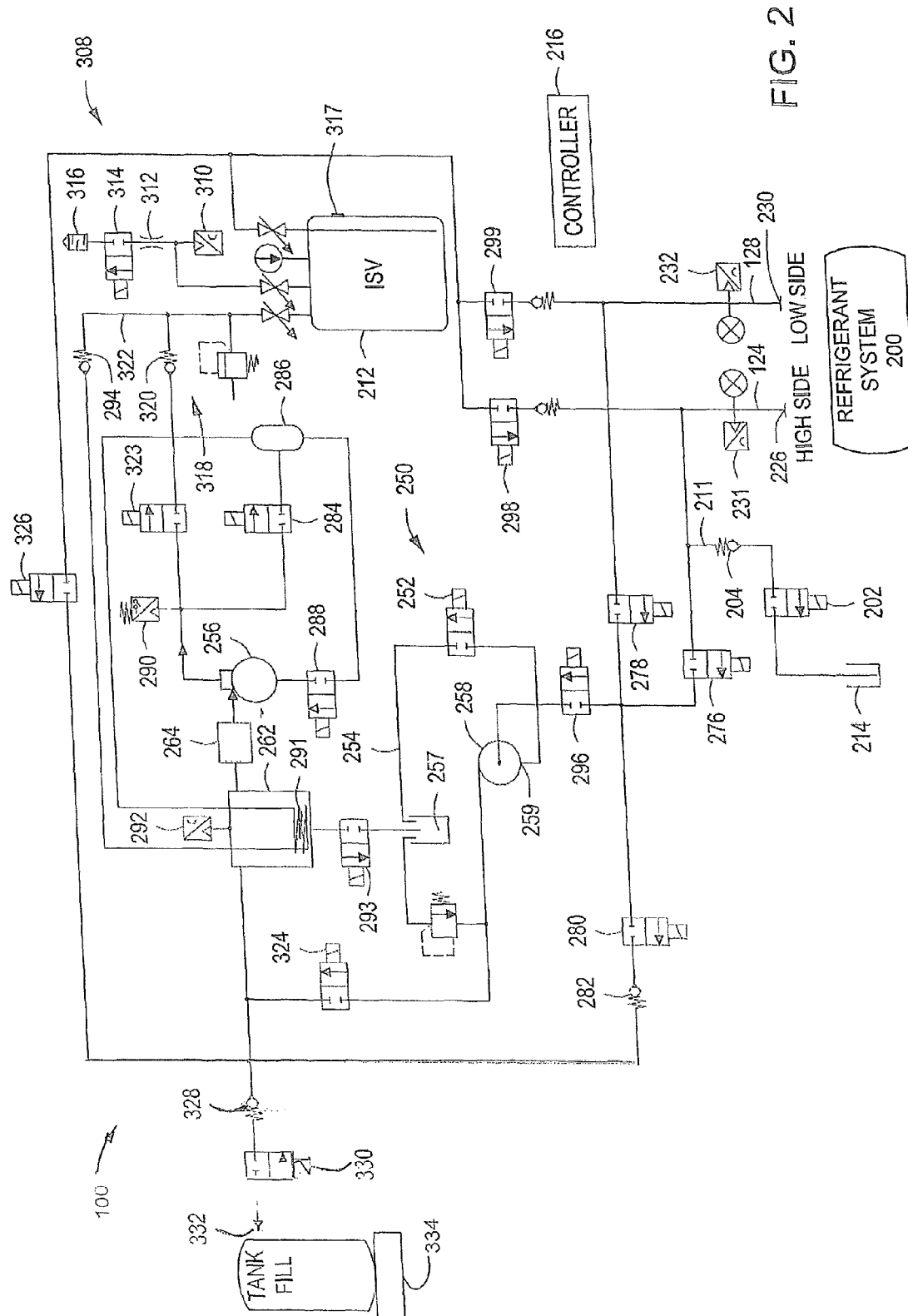


FIG. 1



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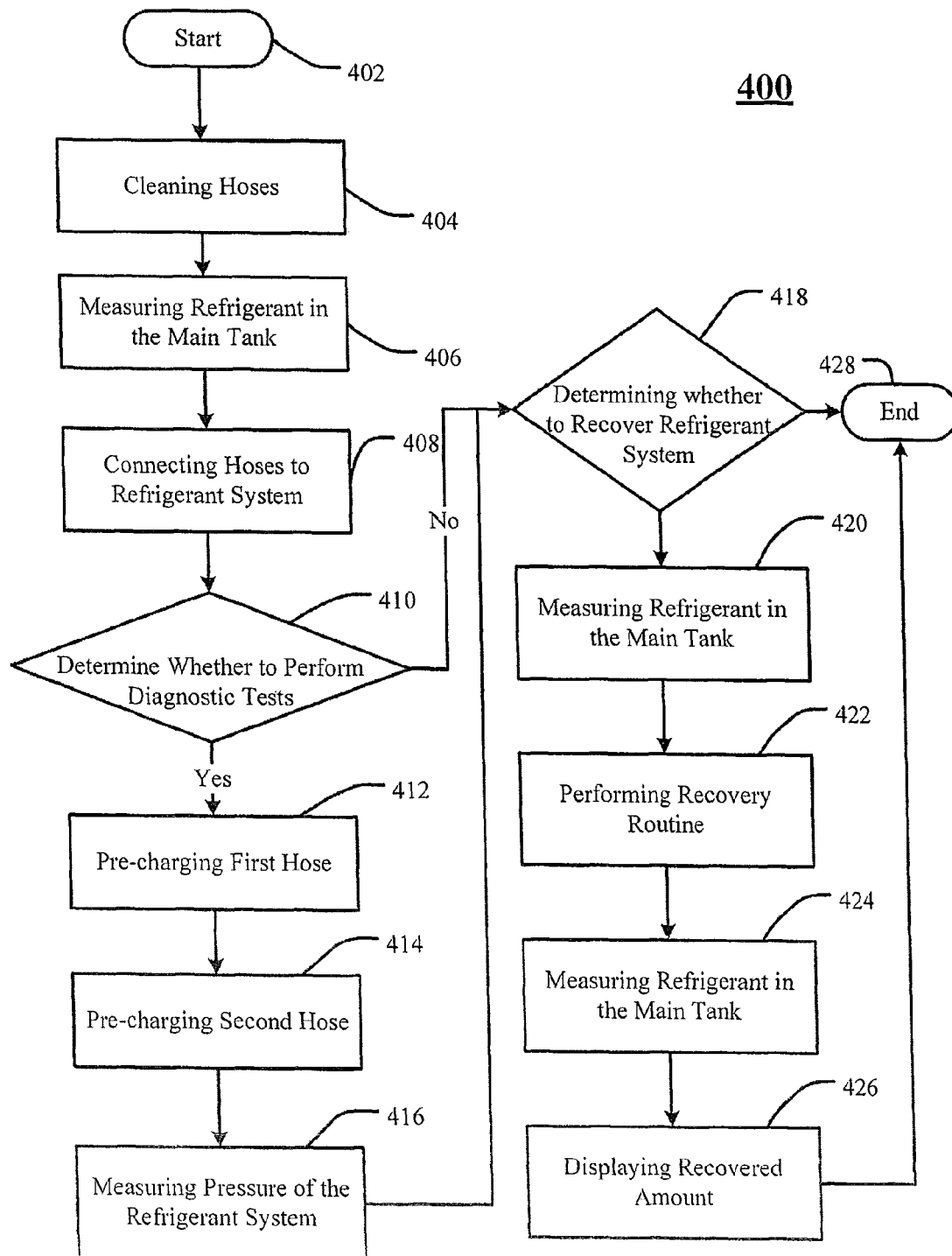


FIG. 3

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METHOD AND APPARATUS FOR IMPROVING ACCURACY OF A/C DIAGNOSTIC TESTS

FIELD OF THE DISCLOSURE

The disclosure generally relates to a refrigerant recovery unit or a refrigerant recovery unit for vehicle air conditioning (A/C) systems, and more particularly to a refrigerant recovery unit that may improve an accuracy of diagnostic tests of the vehicle air condition systems.

BACKGROUND OF THE DISCLOSURE

Vehicle air conditioning (A/C) systems require maintenance, which includes refrigerant recovery, evacuation, recycling and recharging of the A/C systems. The refrigerant recovery unit may be portable and may connect to the A/C system of the vehicle to recover refrigerant out of the system, separate out contaminants and oil, and recharge the A/C system with additional refrigerant.

Also, the refrigerant recovery unit may perform diagnostic tests on the A/C system of the vehicles in order to determine faults of the A/C system. Conventionally, the refrigerant recovery unit may be coupled to the A/C system of the vehicle in order to measure a pressure of the A/C system. The refrigerant recovery unit may utilize the measured pressure to troubleshoot faults in the A/C system. However, the pressure of the A/C system measured by the refrigerant recovery unit may not be accurate because the measured pressure may be significantly affected by the performance of the A/C system. For example, refrigerant may leak from the A/C system into the service hoses of the refrigerant recovery unit and thus, may cause an inaccurate diagnostic test.

For example, the pressure of the A/C system may be measured based on an amount of refrigerant that travels from the A/C system to the refrigerant recovery unit. However, the A/C system's performance may significantly affect an amount of refrigerant that travels from the A/C system to the refrigerant recovery unit and thus, affect the measured pressure of the A/C system. Therefore, a need exists for an accurate and easy diagnostic test for A/C system of vehicles using the refrigerant recovery unit.

SUMMARY OF THE DISCLOSURE

The foregoing needs are met, to a great extent, by the present disclosure, wherein in one aspect, an apparatus and a method are provided that in some embodiments include a refrigerant recovery unit or a refrigerant recovery unit that improves the accuracy of A/C system diagnostic.

In accordance with one embodiment of the present invention, a method for performing a diagnostic test of a refrigerant system, the method may include the steps of: measuring a first amount of refrigerant in a storage tank with a scale of a refrigerant recovery unit, pre-charging a first service hose with a first predetermined amount of refrigerant from the storage tank of the refrigerant recovery unit, pre-charging a second service hose with a second predetermined amount of refrigerant from the storage tank of the refrigerant recovery unit, recovering refrigerant from the refrigerant system into the storage tank using the first service hose and the second service hose, measuring a second amount of refrigerant in the storage tank after recovering the refrigerant with the scale of the refrigerant recovery unit, and determining, with a processor of the refrigerant recovery unit, a recovered amount of

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refrigerant based at least in part on the first amount of refrigerant in the storage tank and the second amount of refrigerant in the storage tank.

In accordance with another embodiment of the present disclosure, an apparatus is provided for performing a diagnostic test on a refrigerant system including a first service hose configured to connect to a first port of the refrigerant system, wherein the first service hose is pre-charged with a first amount of refrigerant from a storage tank, a second service hose configured to connect to a second port of the refrigerant system, wherein the second service hose is pre-charged with a second amount of refrigerant from the storage tank, a compressor configured to recover refrigerant from the refrigerant system to the storage tank using the first service hose and the second service hose, a scale configured to measure a first amount of refrigerant in the storage tank before recovering the refrigerant and measuring second amount of refrigerant in the storage tank after recovering the refrigerant, and a controller configured to determine a recovered amount of refrigerant based at least in part on the first amount of refrigerant in the storage tank and the second amount of refrigerant in the storage tank.

In accordance with yet another embodiment of the present disclosure, an apparatus is provided for performing a diagnostic test of a refrigerant system including first means for connecting to a first port of the refrigerant system, wherein the first means for connecting is pre-charged with a first amount of refrigerant from means for storing, second means for connecting to a second port of the refrigerant system, wherein the second means for connecting is pre-charged with a second amount of refrigerant from the means for storing, means for compressing configured to recover refrigerant from the refrigerant system to the means for storing using the first means for connecting and the second means for connecting, means for measuring a first amount of refrigerant in the means for storing before recovering the refrigerant and measuring a second amount of refrigerant in the means for storing after recovering the refrigerant, and means for controlling configured to determine a recovered amount of refrigerant based at least in part on the first amount of refrigerant in the means for storing and the second amount of refrigerant in the means for storing.

There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of the construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the

claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a refrigerant recovery unit according to an exemplary embodiment of the present disclosure.

FIG. 2 illustrates components of the refrigerant recovery unit shown in FIG. 1 according to an exemplary embodiment of the present disclosure.

FIG. 3 is a flow diagram for improving accuracy of A/C diagnostic tests according to an exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

An apparatus and method are developed to improve accuracy of diagnostic tests for A/C systems. In particular, a refrigerant recovery unit may have its hoses pre-charged with a refrigerant to a predetermined pressure or amount before performing the diagnostic tests on the A/C system of the vehicle. For example, a predetermined amount of refrigerant may be injected into the hoses of the refrigerant recovery unit to pre-charge them. The pre-charged hoses of the refrigerant recovery unit may prevent a refrigerant flow from the A/C system to the hoses connected thereto before the diagnostic tests are implemented and thus, improve the accuracy of the diagnostic tests.

Currently, the most common refrigerant used in vehicle refrigerant systems is the HFC-134a. However, new refrigerants are being introduced in order to decrease global warming that can be caused by HFC-134a. These new refrigerants, for example, include HFO-1234yf and R-152a, and can also be used in the various embodiments described herein.

FIG. 1 is a perspective view illustrating a refrigerant recovery unit **100** according to an embodiment of the present disclosure. The refrigerant recovery unit **100** can be the CoolTech 34788™ from Robinair™ based in Owatonna, Minn. (a business unit of SPX Corporation). The refrigerant recovery unit **100** includes a cabinet **102** to house components of the system (See FIG. 2). The cabinet **102** may be made of any material such as thermoplastic, steel and the like.

The cabinet **102** includes a control panel **104** that allows the user to operate the refrigerant recovery unit **100**. The control panel **104** may be part of the cabinet as shown in FIG. 1 or separated. The control panel **104** includes high and low gauges **106**, **108**, respectively. The gauges may be analog or digital as desired by the user. The control panel **104** has a display **110** to provide information to the user, such as certain operating status of the refrigerant recovery unit **100** or provide messages or menus to the user. Located near the display **110** are LEDs **112** to indicate to the user the operational status of the refrigerant recovery unit **100**. A user interface **114** is also included on the control panel **104**. The user interface **114** allows the user to interact and operate the refrigerant recovery unit **100** and can include an alphanumeric keypad and directional arrows.

The cabinet **102** further includes connections for hoses **124**, **128** that connect the refrigerant recovery unit **100** to a refrigerant containing device, such as the vehicle's refrigerant system **200** (shown in FIG. 2). In order for the refrigerant recovery unit **100** to be mobile, wheels **120** are provided at a bottom portion of the system.

FIG. 2 illustrates components of the refrigerant recovery unit **100** of FIG. 1 according to an embodiment of the present disclosure. In one embodiment, to recover refrigerant, service hoses **124** and **128** are coupled to the refrigeration system **200** of the vehicle, via couplers **226** (high side) and **230** (low side), respectively. The couplers are designed to be closed until they are coupled to the refrigerant system **200**.

The recovery cycle is initiated by the opening of high pressure and low-pressure solenoids **276**, **278**, respectively. This allows the refrigerant within the vehicle's refrigeration system **200** to flow through a recovery valve **280** and a check valve **282**. The refrigerant flows from the check valve **282** into a system oil separator **262**, where it travels through a filter/dryer **264**, to an input of a compressor **256**. Refrigerant is drawn through the compressor **256** through a normal discharge solenoid **284** and through a compressor oil separator **286**, which circulates oil back to the compressor **256** through an oil return valve **288**. The refrigerant recovery unit **100** may include a high-pressure switch **290** in communication with a controller **216**, which is programmed to determine an upper pressure limit, for example, 435 psi, to optionally shut down the compressor **256** to protect the compressor **256** from excessive pressure. The controller **216** can also be, for example, a microprocessor, a field programmable gate array (FPGA) or application-specific integrated circuit (ASIC). The controller **216** via a wired or wireless connection (not shown) controls the various valves and other components (e.g. vacuum, compressor) of the refrigerant recovery unit **100**. In some embodiments of the present disclosure, any or all of the electronic solenoid or electrically activated valves may be connected and controlled by the controller **216**.

A high-side clear solenoid (not shown) may optionally be coupled to the output of the compressor **256** to release the recovered refrigerant transferred from compressor **256** directly into a storage tank **212**, instead of through a path through the normal discharge solenoid **284**.

The heated compressed refrigerant exits the oil separator **286** and then travels through a loop of conduit or heat exchanger **291** for cooling or condensing. As the heated refrigerant flows through the heat exchanger **291**, the heated refrigerant gives off heat to the cold refrigerant in the system oil separator **262**, and assists in maintaining the temperature in the system oil separator **262** within a working range. Coupled to the system oil separator **262** is a switch or transducer **292**, such as a low pressure switch or pressure transducer, for example, that senses pressure information, and provides an output signal to the controller **216** through a suitable interface circuit programmed to detect when the pressure of the recovered refrigerant is down to 13 inches of mercury, for example. An oil separator drain valve **293** drains the recovered oil into the container **257**. Finally, the recovered refrigerant flows through a normal discharge check valve **294** and into the storage tank **212**.

The evacuation cycle begins by the opening of high pressure and low-pressure solenoids **276** and **278** and valve **296**, leading to the input of a vacuum pump **258**. Prior to opening valve **296**, an air intake valve (not shown) is opened, allowing the vacuum pump **258** to start exhausting air. The vehicle's refrigerant system **200** is then evacuated by the closing of the air intake valve and opening the valve **296**, allowing the vacuum pump **258** to exhaust any trace gases remaining until the pressure is approximately 29 inches of mercury, for example. When this occurs, as detected by pressure transducers **231** and **232**, optionally, coupled to the high side **226** and low side **230** of the vehicle's refrigeration system **200** and to the controller **216**, the controller **216** turns off valve **296** and this begins the recharging cycle.

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The recharging cycle begins by opening charge valve **298** to allow the refrigerant in storage tank **212**, which is at a pressure of approximately 70 psi or above, to flow through the high side of the vehicle's refrigeration system **200**. The flow is through charge valve **298** for a period of time programmed to provide full charge of refrigerant to the vehicle. Optionally, charge valve **299** may be opened to charge the low side. The charge valve **299** may be opened alone or in conjunction with charge valve **298** to charge the vehicle's refrigerant system **200**. The storage tank **312** may be disposed on a scale **334** that measure the weight of the refrigerant in the storage tank.

Other components shown in FIG. 2 include an oil inject circuit having an oil inject valve **202** and an oil inject hose or line **211**. The oil inject hose **211** is one example of a fluid transportation means for transmitting oil for the refrigerant recovery unit **100**. The oil inject hose **211** may be one length of hose or multiple lengths of hose or tubing or any other suitable means for transporting fluid. The oil inject hose **211** connects on one end to an oil inject bottle **214** and on the other end couples to the refrigerant circuit in the refrigerant recovery unit **100**. Disposed along the length of the oil inject hose **211** are the oil inject valve **202** and an oil check valve **204**. The oil inject path follows from the oil inject bottle **214**, through the oil inject solenoid **202**, to the junction with the high side charge line, and to the vehicle's refrigerant system **200**.

FIG. 2 also illustrates a vacuum pump oil drain circuitry **250** that includes a vacuum pump oil drain valve **252** that is located along a vacuum pump oil drain conduit **254** connecting a vacuum pump oil drain outlet **259** to a container **257** for containing the drained vacuum pump oil. The vacuum pump oil drain valve **252** may be an electronically activated solenoid valve controlled by controller **216**. The connection may be a wireless or wired connection. In other embodiments the valve **252** may be a manually activated valve and manually actuated by a user. The conduit **254** may be a flexible hose or any other suitable conduit for provided fluid communication between the outlet **256** and the container **257**.

FIG. 2 also illustrates an air purging apparatus **308**. The air purging apparatus **308** allows the refrigerant recovery unit **100** to be purged of non-condensable, such as air. Air purged from the refrigerant recovery unit **100** may exit the storage tank **212**, through an orifice **312**, through a purging valve **314** and through an air diffuser **316**. In some embodiments, the orifice may be 0.028 of an inch. A pressure transducer **310** may measure the pressure contained within the storage tank **212** and purge apparatus **308**. The pressure transducer **310** may send the pressure information to the controller **216**. And when the pressure is too high, as calculated by the controller, purging is required. The valve **314** may be selectively actuated to permit or not permit purging apparatus **308** to be open to the ambient conditions. A temperature sensor **317** may be coupled to the main tank to measure the refrigerant temperature therein. The placement of the temperature sensor **317** may be anywhere on the tank or alternatively, the temperature sensor may be placed within a refrigerant line **322**. The measured temperature and pressure may be used to calculate the ideal vapor pressure for the type of refrigerant used in the refrigerant recovery unit. The ideal vapor pressure can be used to determine when the non-condensable gases need to be purged and how much purging will be done in order to get the refrigerant recovery unit to function properly.

High side clearing valves **318** may be used to clear out part of the high-pressure side of the system. The high side clearing valves **318** may include valve **323** and check valve **320**. Valve **323** may be a solenoid valve. When it is desired to clear part of the high side, valve **323** is opened. Operation of the compressor **256** will force refrigerant out of the high pressure side

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through valves **323** and **320** and into the storage tank **212**. During this procedure the normal discharge valve **284** may be closed.

A deep recovery valve **324** is provided to assist in the deep recovery of refrigerant. When the refrigerant from the refrigerant system **200** has, for the most part, entered into the refrigerant recovery unit **100**, the remaining refrigerant may be extracted from the refrigerant system **200** by opening the deep recovery valve **324** and turning on the vacuum pump **258**.

In another embodiment, in order to charge the refrigerant system **200**, the power charge valve **326** may be opened and a tank fill structure **332** may be used. Alternatively or in addition to, the tank fill structure **332** may also be used to fill the storage tank **312**. In order to obtain refrigerant from a refrigerant source, the refrigerant recovery unit **100** may include the tank fill structure **332**, and valves **328** and **330**. The tank fill structure **332** may be configured to attach to a refrigerant source. The valve **330** may be a solenoid valve and the valve **328** may be a check valve. In other embodiments, valve **330** may be a manually operated valve.

When it is desired to allow refrigerant from a refrigerant source to enter the refrigerant recovery unit **100**, the tank fill structure **332** is attached to the refrigerant source and the tank fill valve **330** is opened. The check valve **328** prevents refrigerant from the refrigerant recovery unit **100** from flowing out of the refrigerant recovery unit **100** through the tank fill structure **332**. When the tank fill structure **332** is not connected to a refrigerant source, the tank fill valve **330** is kept closed. The tank fill valve **330** may be connected to and controlled by the controller **216**.

The tank fill structure **332** may be configured to be seated on the scale **334** configured to weigh the tank fill structure **332** in order to determine an amount of refrigerant stored in the tank fill structure **332**. The scale **334** may be operatively coupled to the controller **216** and provide a measurement of a weight of the tank fill structure **332** to the controller **216**. The controller **216** may cause a display of the weight of the tank fill structure **332**.

FIG. 3 is a flow diagram for improving accuracy of A/C diagnostic tests according to an embodiment of the present disclosure. This exemplary method **400** may be provided by way of example, as there are a variety of ways to carry out the method. The method **400** shown in FIG. 3 can be executed or otherwise performed by one or a combination of various systems. The method **400** is described below may be carried out by the system and components shown in FIGS. 1-2, by way of example, and various elements of the system are referenced in explaining the exemplary method of FIG. 3. Each block shown in FIG. 3 represents one or more processes, methods, or subroutines carried out in exemplary method **400**. However, the steps do not have to be performed in any certain order or performed at all.

At step **402**, the method **400** for performing an improved diagnostic test of a refrigerant system **200** of a vehicle may begin.

At step **404**, service hoses are cleaned. Service hoses **124** and **128** of the refrigerant recovery unit **100** may be cleaned before performing the diagnostic test on the refrigerant system **200**. For example, oils and contaminants from the service hoses **124** and **128** and associated refrigerant control circuit are flushed and the service hoses **124** and **128** are cleaned. Also, any remnants of refrigerants that may remain in the service hoses **124** and **128** may be cleaned or flushed out before performing the diagnostic test on the refrigerant system **200** in order to achieve accurate diagnostic results. For example, the refrigerant recovery unit **100** may inject refrigerant

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erant into one of the service hoses **128** (e.g., low pressure service hose) and out of one of the service hoses **124** (e.g., high pressure service hose) when they are coupled together. The refrigerant recovery unit **100** may continue to inject refrigerant into the service hoses **124** and **128** until oil and containments are flushed out of the service hoses **124** and **128**. In an exemplary embodiment, a method of cleaning the service hoses **124** and **128** is disclosed in U.S. patent application Ser. No. 12/248,352, which is incorporated by reference in its entirety. Step **404** does not have to be performed if for example, the hoses are new or the refrigerant recovery unit **100** is new. After, cleaning the service hoses **124** and **128**, the method **400** may proceed to step **406**.

At step **406**, an amount of refrigerant stored in the tank fill structure or storage tank may be measured. For example, the refrigerant recovery unit **100** may measure an amount of refrigerant stored in the tank fill structure **332** or storage tank **212** before performing a diagnostic test on the refrigerant system **200**. In an exemplary embodiment, the scale **334** may measure the weight of art amount of refrigerant stored in the tank fill structure **332** or storage tank **212** and may provide the weight to the controller **216** for storing and processing. After measuring an amount of refrigerant stored in the tank fill structure, the method **400** may proceed to step **408**.

At step **408**, the service hoses are connected to the refrigerant system **200**. For example, service hose **124** (e.g., high pressure service hose and red color) may be coupled to a high-pressure fluid transmitting port of the refrigerant system **200** via the coupler **226**. Service hose **128** (e.g., low pressure service hose and blue color) may be coupled to a low-pressure fluid transmitting port of the refrigerant system **200** via the coupler **230**. After connecting the service hoses **124** and **128** to the refrigerant system **200**, the method **400** may proceed to step **410**.

At step **410**, whether to perform a diagnostic test of the refrigerant system **200** may be determined. For example, the refrigerant recovery unit **100** may receive a selection to perform a diagnostic test on the refrigerant system **200** or may receive a selection to recover refrigerant from the refrigerant system **200**. In the event that the refrigerant recovery unit **100** determines to perform a diagnostic test on the refrigerant system **200**, the method **400** may proceed to step **412**. In the event that the refrigerant recovery unit **100** determines not to perform a diagnostic test on the refrigerant system **200**, the method **400** may proceed to step **418**.

At step **412**, a first service hose may be pre-charged before the diagnostic test commences. For example, a high-pressure service hose **124** (e.g., red color coded) may be pre-charged with a predetermined or programmable amount of refrigerant or pressure from the tank fill structure **332** or storage tank **212**. In an exemplary embodiment, the high-pressure service hose **124** may be pre-charged to a pressure of 110-130 psi with approximately 60 grams of refrigerant. For example, an amount of refrigerant pre-charged into the high-pressure service hose **124** may vary based on the ambient temperature. Open the valve **298** or the valve **299**. By pre-charging the service hose **124**, the amount of refrigerant in the refrigerant system **200** will not change during the diagnostic test. Often, when the services hoses **124** and **128** are hooked up to the refrigerant system **200** for testing, refrigerant from the refrigerant system **200** may leak into the service hoses **124** and **128** before the diagnostic test and thus, inaccurate measurements (i.e. the amount of refrigerant in the system) of the refrigerant system **200** can occur. After pre-charging a first service hose **124**, the method **400** may proceed to step **414**.

At step **414**, a second service hose may be pre-charged. For example, a low-pressure service hose **128** (e.g., blue color

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coded) may be pre-charged with a predetermined or programmable amount of refrigerant or pressure from the tank fill structure **332** or storage tank **212**. In an exemplary embodiment, the low-pressure service hose **128** may be pre-charged to a pressure of 30-40 psi with approximately 1-5 grams of refrigerant. The amount of refrigerant pre-charged into the low-pressure service hose **128** may vary based on the ambient temperature. By pre-charging the service hose **128**, the amount of refrigerant in the refrigerant system **200** will not change during the diagnostic test. After pre-charging a second service hose **128**, the method **400** may proceed to step **416**.

At step **416**, the pressure of the refrigerant system **200** may be measured. For example, the refrigerant system **200** may be initiated and turned to an "ON" state. The refrigerant recovery unit **100** may measure the pressure of the refrigerant system **200**. For example, the pressure transducers **231** and **232** coupled to the service hoses **124** and **128** may measure the pressure of the refrigerant system **200** after the refrigerant system **200** is turned to the "ON" state. During the diagnostic test, an amount of refrigerant in the refrigerant system **200** should not change because the first service hose **124** and the second service hose **128** are pre-charged with refrigerant from the tank fill structure **332** or storage tank **312**. Thus, a more accurate pressure reading of the refrigerant system **200** may be determined by the refrigerant recovery unit **100**. After measuring pressure of the refrigerant system **200**, the method **400** may proceed to step **418**.

At step **418**, whether to recover the refrigerant system **200** may be determined. During the recovery cycle, the refrigerant located within the refrigerant system **200** may flow from the refrigerant system **200** to the service hoses **124** and **128** and refrigerant may be recovered by the refrigerant recovery unit **100**, as described above. In the event that the refrigerant system **200** is not recovered, the method **400** may proceed to step **428** and end. In the event that the refrigerant system **200** is recovered, the method **400** may proceed to step **420**.

At step **420**, the amount of refrigerant left in the tank fill structure **332** or storage tank **212** after pre-charging the service hoses **124** and **128** may be measured. For example, the scale **334** may measure the weight of the refrigerant left in the tank fill structure **332** or storage tank **212** after pre-charging the service hoses **124** and **128** and may provide the weight to the controller **216** for storing and processing. After measuring the amount of refrigerant left in the tank fill structure **332** or storage tank **312** after pre-charging the service hoses **124** and **128**, the method **400** may proceed to step **422**.

At step **422**, recovery of refrigerant from the refrigerant system **200** may be performed. For example, the recovery cycle is initiated by connecting service hoses **124** and **128** to the refrigerant system **200**, if they are not already connected. This allows the refrigerant within the refrigerant system **200** to flow through a refrigerant control circuit of the refrigerant recovery unit **100**. The refrigerant may be recovered from the refrigerant system **200** by the refrigerant recovery unit **100**, as described above. After performing recovery of refrigerant from the refrigerant system **200**, the method **400** may proceed to step **424**.

At step **424**, the amount of refrigerant in the tank fill structure **332** or storage tank **212** may be measured after the recovery process. For example, the scale **334** may measure the weight of the refrigerant stored in the tank fill structure **332** or storage tank **212** after the recovery process is performed on the refrigerant system **200** and may provide the weight to the controller **216** for storing and processing. After measuring an amount of refrigerant in the tank fill structure **332** or storage tank **212** after the recovery process, the method **400** may proceed to step **426**.

At step 426, the recovered amount of refrigerant recovered from refrigerant system 200 may be displayed on the display 110. The controller 216 may calculate the amount of refrigerant recovered from the refrigerant system 200 by determining a difference between an amount of refrigerant stored in the tank fill structure 332 or storage tank 212 before the recovery process and an amount of refrigerant stored in the tank fill structure 332 or storage tank 212 after the recovery process. In another example, the controller 216 may calculate the amount of refrigerant recovered from the refrigerant system 200 by subtracting the amount of refrigerant stored in the tank fill structure 332 or storage tank 212 before the recovery process plus the amount of refrigerant pre-charged into both the high pressure and low pressure service hose 124 and 128 from the amount of refrigerant stored in the tank fill structure 332 or storage tank 212 after the recovery process. After displaying the amount of refrigerant recovered from the refrigerant system 200, the method 400 may proceed to step 428 and end.

It can be understood that the method and apparatus for improving accuracy of A/C diagnostic tests of a refrigerant recovery unit described and illustrated herein are examples only. The methods and apparatuses described herein can be used for any refrigerant including R134A, however, the present disclosure can also be used for HFO1234YF, CO₂, and other similar refrigerant systems. It is contemplated and within the scope of the disclosure to construct a wide range of refrigerant recovery unit to meet particular design and requirements in a wide range of applications. A refrigerant recovery unit may be fitted with a single vehicle service hose, for example, to accommodate refrigerant systems having only one port to charge and recover from, and the refrigerant recovery unit may be modified accordingly to flush the one service hose. The service hose(s) may be fitted with fittings other than R134a fittings, such as where other types of refrigerant are used. The construction of the fluid hose for connecting the pair of fluid transmitting ports may have different dimensions or configurations from that illustrated, and its size and shape may vary. The fluid hose may have fittings other than J639 type vehicle ports, and the fluid connector may be bypassed entirely.

The many features and advantages of the invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention, which fall within the true spirit, and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed is:

1. An apparatus for performing a diagnostic test on a refrigerant system, comprising:
 - a first service hose configured to connect to a first port of the refrigerant system, the first service hose being pre-charged with a first amount of refrigerant from a storage tank before performing the diagnostic test, wherein the first amount of refrigerant is based on an ambient temperature;
 - a second service hose configured to connect to a second port of the refrigerant system, the second service hose being pre-charged with a second amount of refrigerant from the storage tank before performing the diagnostic test, wherein the second amount of refrigerant is based on the ambient temperature;

- a compressor configured to recover refrigerant from the refrigerant system to the storage tank using the first service hose and the second service hose;
 - a scale configured to measure a pre-recovery amount of refrigerant in the storage tank before recovering the refrigerant, measure a post-recovery amount of refrigerant in the storage tank after recovering the refrigerant, and measure a third amount of refrigerant in the storage tank after pre-charging the first service hose and the second service hose; and
 - a controller configured to determine a recovered amount of refrigerant, wherein the recovered amount of refrigerant is a difference determined by subtracting the pre-recovery amount of refrigerant stored in the storage tank plus the amount of refrigerant pre-charged into the first service hose and the second service hose from the post-recovery amount of refrigerant stored in the storage tank.
2. The apparatus according to claim 1, wherein the controller conducts the diagnostic test on the refrigerant system after the first service hose and the second service hose are pre-charged.
 3. The apparatus according to claim 1, further comprising an oil separator for separating oil from the recovered refrigerant.
 4. The apparatus according to claim 1, wherein the first service hose and the second service hose are cleaned before charging the refrigerant system.
 5. The apparatus of claim 1, wherein the precharged first and second service hoses prevent refrigerant from the refrigerant system from entering the first and second service hoses before the diagnostic test is conducted.
 6. An apparatus for performing a diagnostic test of a refrigerant system, comprising:
 - first means for connecting to a first port of the refrigerant system, wherein the first means for connecting being pre-charged with a first amount of refrigerant from means for storing;
 - second means for connecting to a second port of the refrigerant system, the second means for connecting being pre-charged with a second amount of refrigerant from the means for storing;
 - means for compressing configured to recover refrigerant from the refrigerant system to the means for storing using the first means for connecting and the second means for connecting;
 - means for measuring a pre-recovery amount of refrigerant in the means for storing before recovering the refrigerant, a post-recovery amount of refrigerant in the means for storing after recovering the refrigerant, and a third amount of refrigerant in the means for storing after pre-charging the first means for connecting and the second means for connecting; and
 - means for controlling configured to determine a recovered amount of refrigerant, wherein the recovered amount of refrigerant is a difference determined by subtracting the pre-recovery amount of refrigerant stored in the means for storing plus the amount of refrigerant pre-charged into the first means for connecting and the second means for connecting from the post-recovery of refrigerant stored in the means for storing.
 7. The apparatus according to claim 6, wherein the means for controlling conducts the diagnostic test on the refrigerant system after the first means for connecting and the second means for connecting are pre-charged.

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8. The apparatus according to claim 6, further comprising an oil separator for separating oil from the recovered refrigerant.

9. The apparatus according to claim 6, wherein the first means for connecting and the second means for connecting 5 are cleaned before charging the refrigerant system.

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